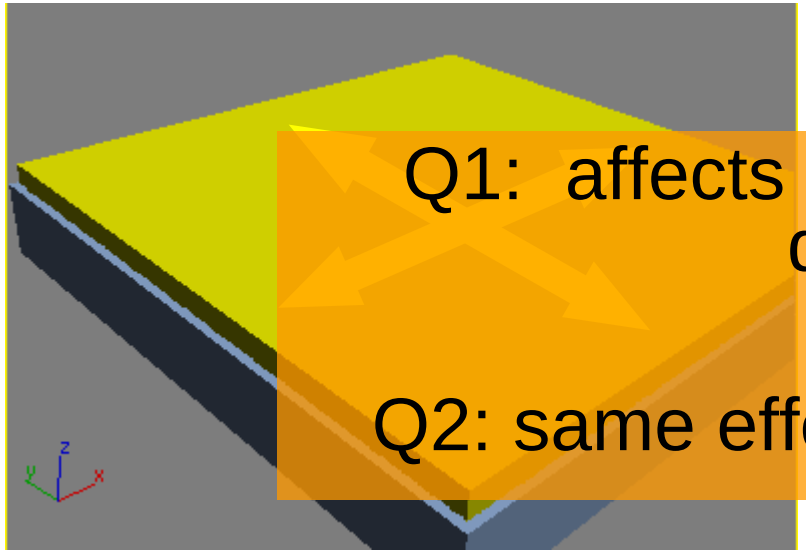
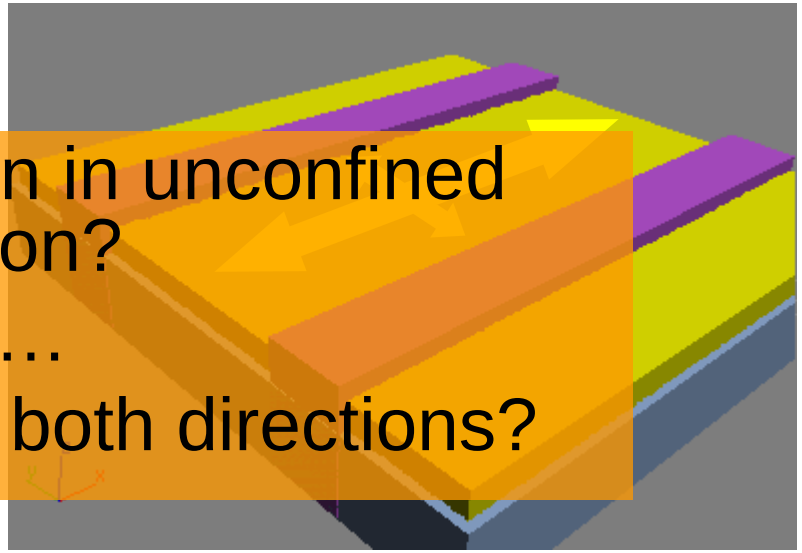
1-D confined liquid anisotropic dynamics

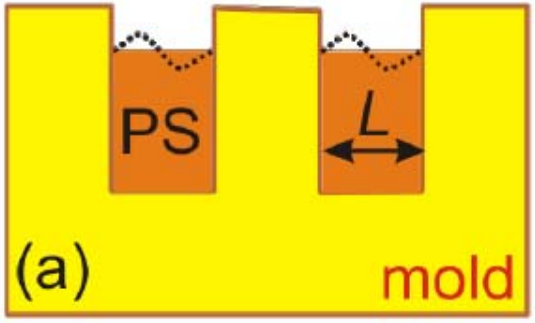


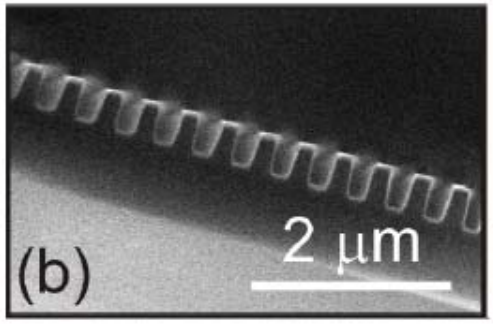


Q1: affects motion in unconfined direction?

If so…

Q2: same effect in both directions?





X-ray Photon Correlation Spectroscopy (XPCS)

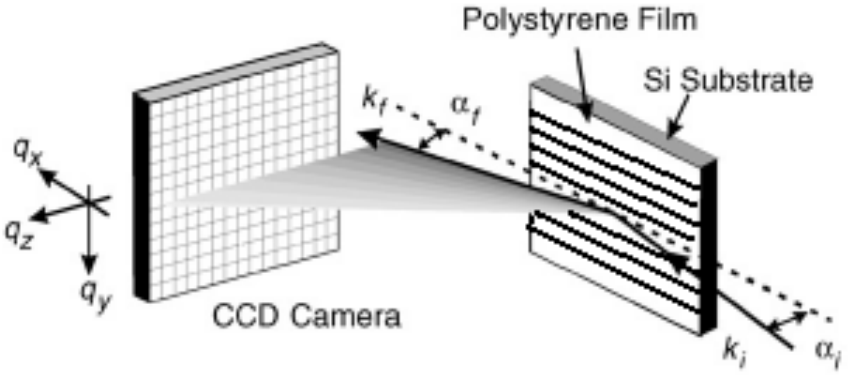
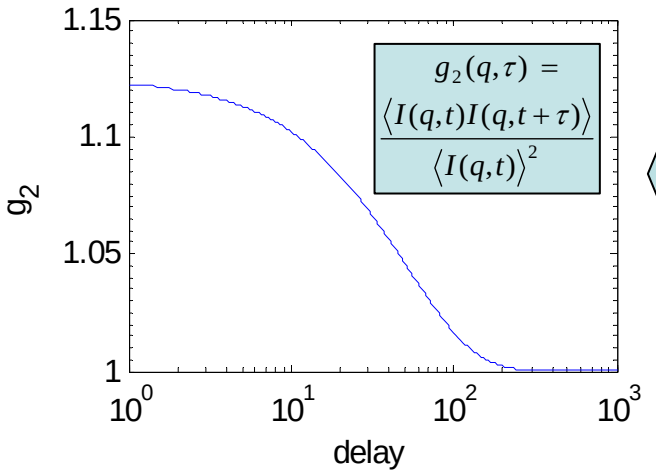
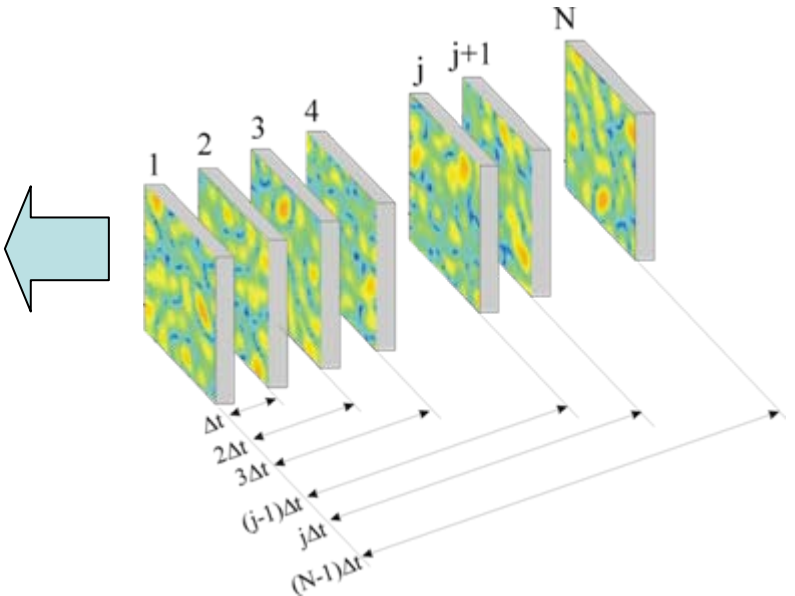


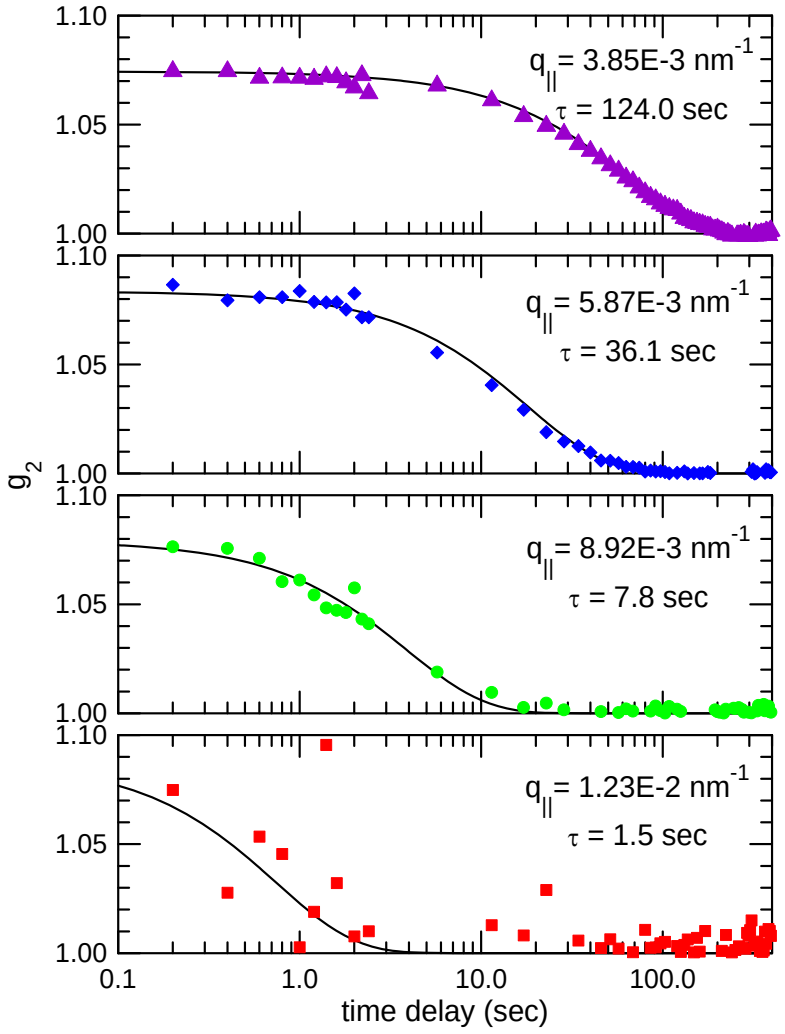
Fig. 1. The experimental setup for XPCS in reflectivity geometry.

Intensity-intensity auto correlation





Intensity-intensity Auto-correlation Function



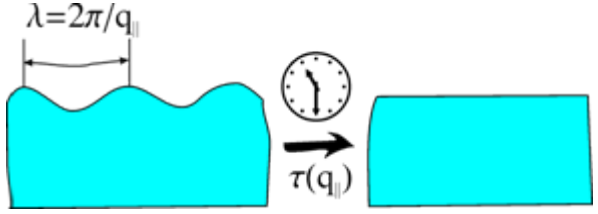
- h=84 nm, T=160 °C (>>Tg)
- Autocorrelation function

$$g_2(q_{||},t) = 1 + \beta \left| f(q_{||},t) \right|^2$$

- Intermediate scattering function

$$f(q_{||},t) = \exp[-(t/\tau)^{\alpha}]$$

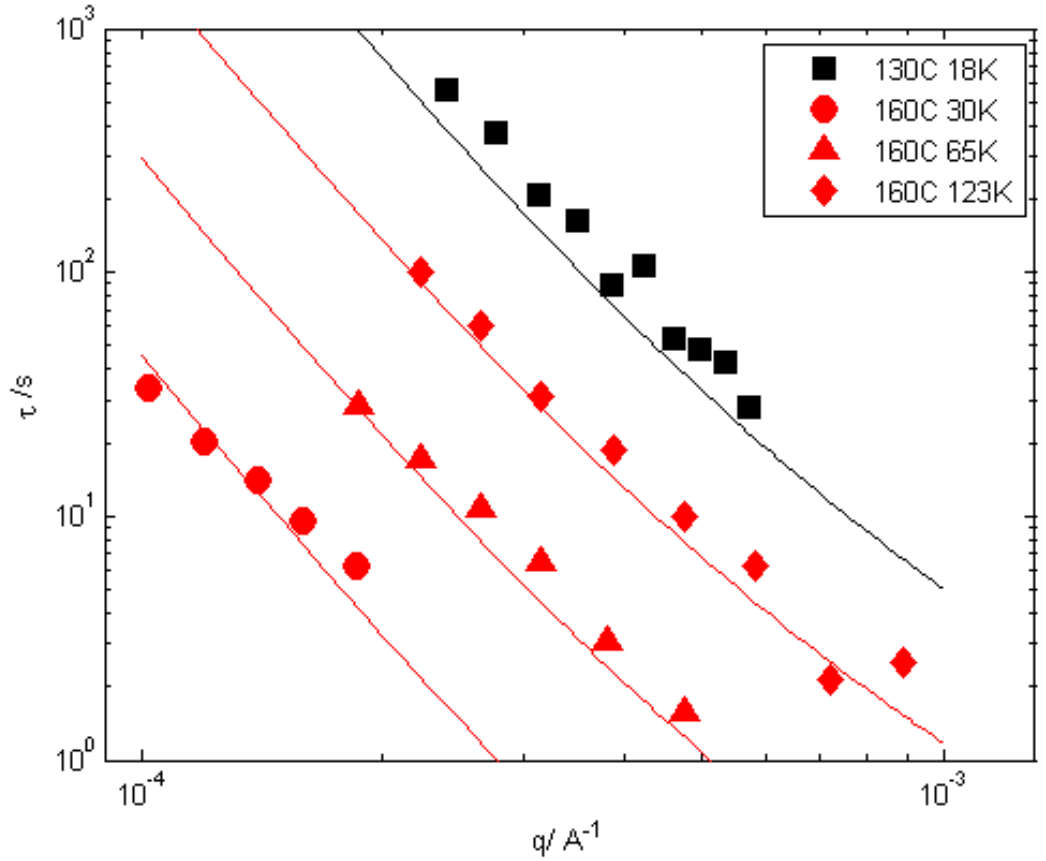
- β: speckle contrast
- α: stretching exponent; α≅1
- τ: over-damped relaxation time constant



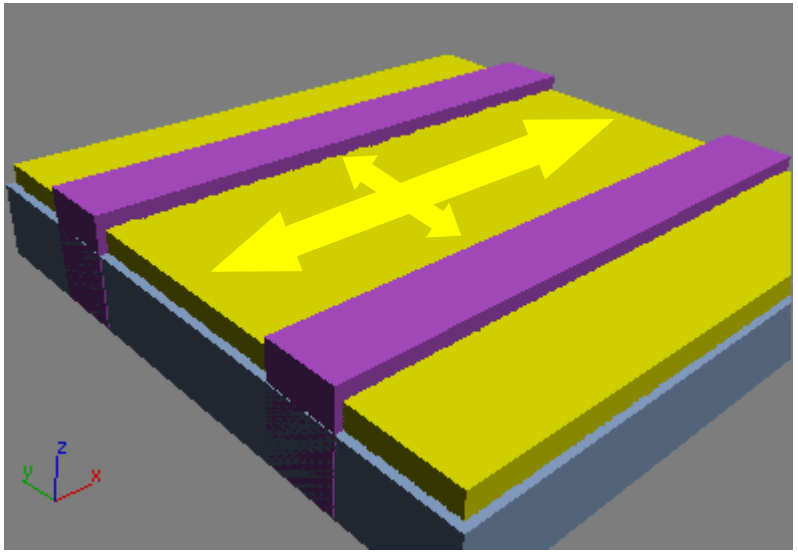
➢ Hyunjung Kim, et al., Phys. Rev. Lett. 90, 68302 (2003)

Lines Calculated from theory
red – Hyunjung's data(170nm@160C), black – our film(180nm@130C)

$$\tau \approx 2\eta(\cosh^2(q_\parallel h) + (q_\parallel h)^2)/\gamma q_\parallel(\sinh(q_\parallel h) \times \cosh(q_\parallel h) - q_\parallel h),$$



Tg=100
Eta=4.36e5 pa*s
Film =180nm from XR

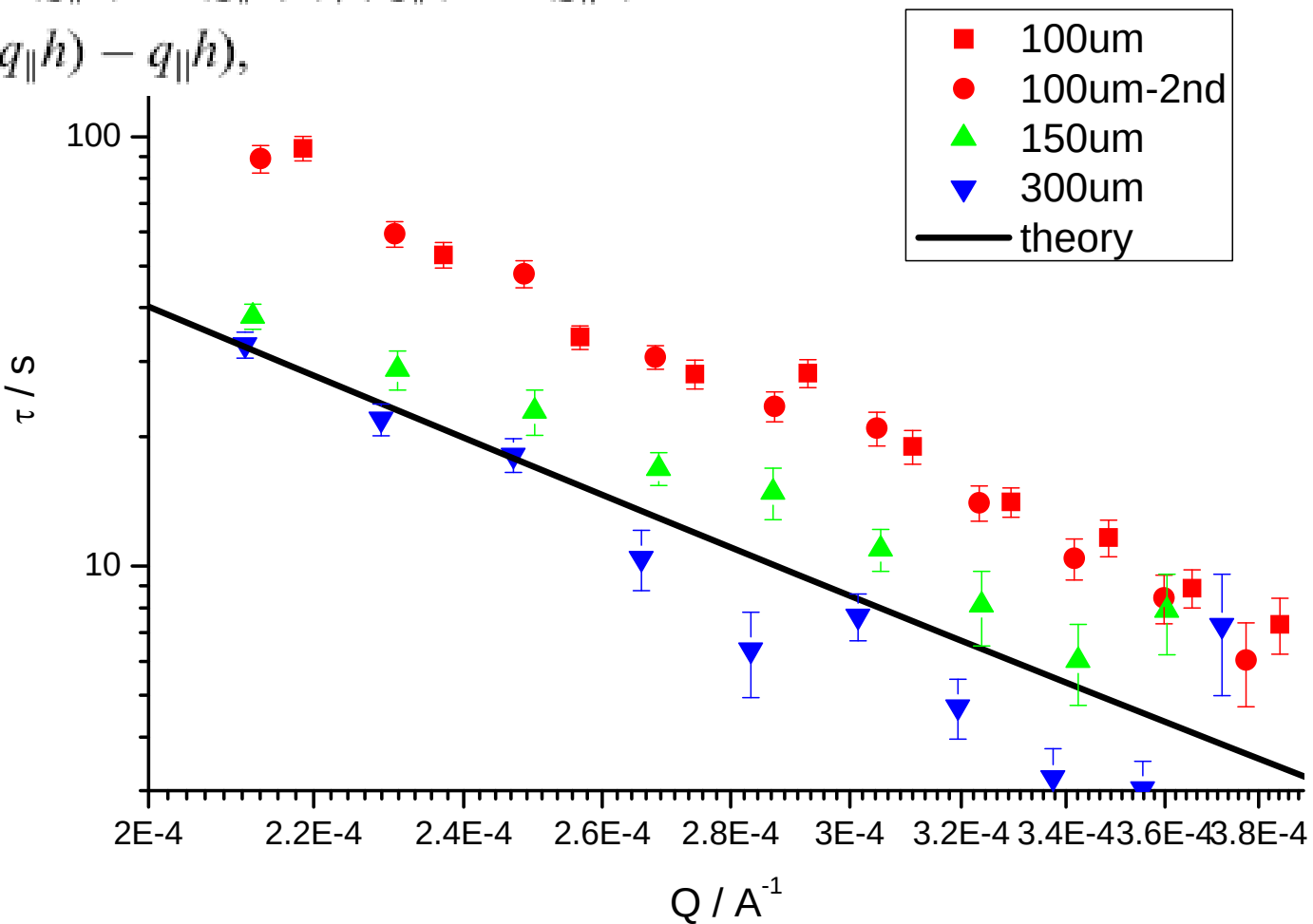


Completely frozen in 135nm channels, except overfilled samples

static in 7.5um channels

large channels @ 150C: 100um~300um width and 300nm depth 18k PS, thickness 94~100nm from XR

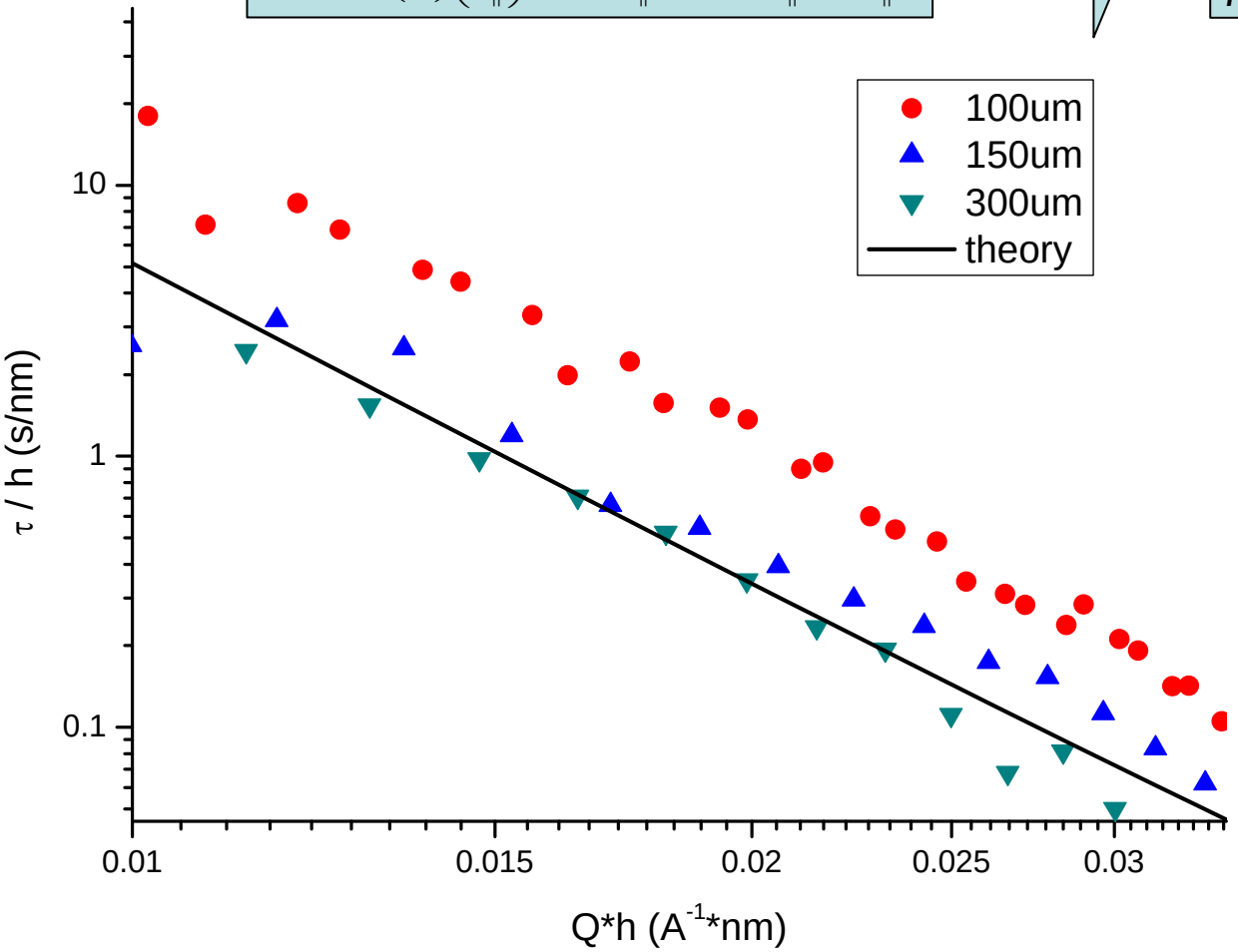
$$\tau \approx 2\eta(\cosh^2(q_{\|}h) + (q_{\|}h)^2)/\gamma q_{\|}(\sinh(q_{\|}h) \times \cosh(q_{\|}h) - q_{\|}h),$$



Thickness scaling

$$\tau(q_{\|}) \cong 2\left(\frac{\eta}{\gamma}\right)\left(\frac{1}{q_{\|}}\right)\frac{[\cos(q_{\|}h)^2 + (q_{\|}h)^2]}{[\sinh(q_{\|}h)\cosh(q_{\|}h) - q_{\|}h]}$$

$$\frac{\tau}{h} = f(q_{\|}h)$$



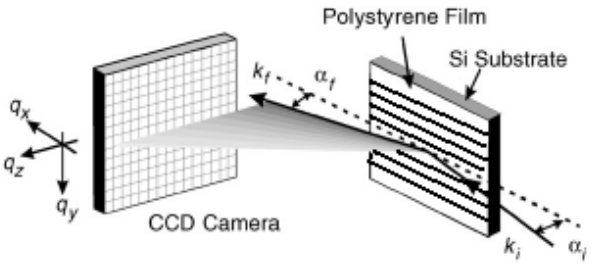


Fig. 1. The experimental setup for XPCS in reflectivity geometry.

A1: Confinement affects Capillary motion in the Unconfined direction!

directional dependence
18k PS in 300um @ 150C

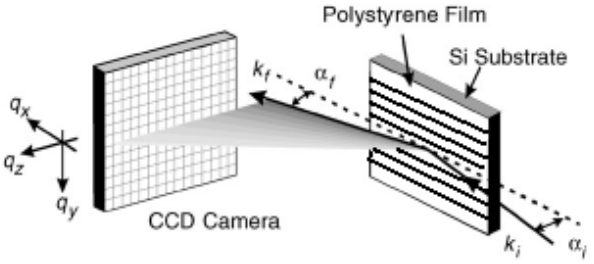
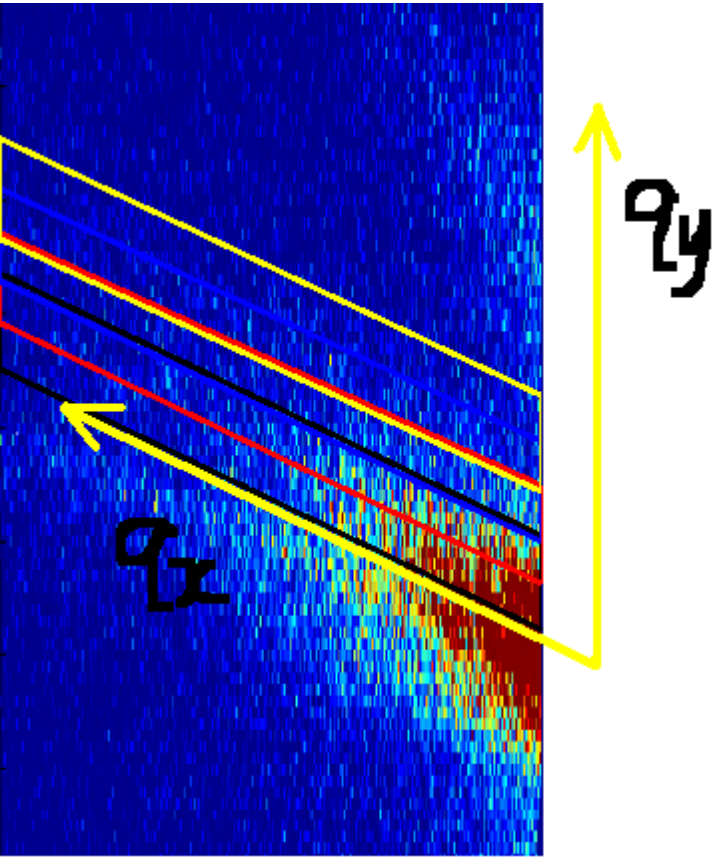
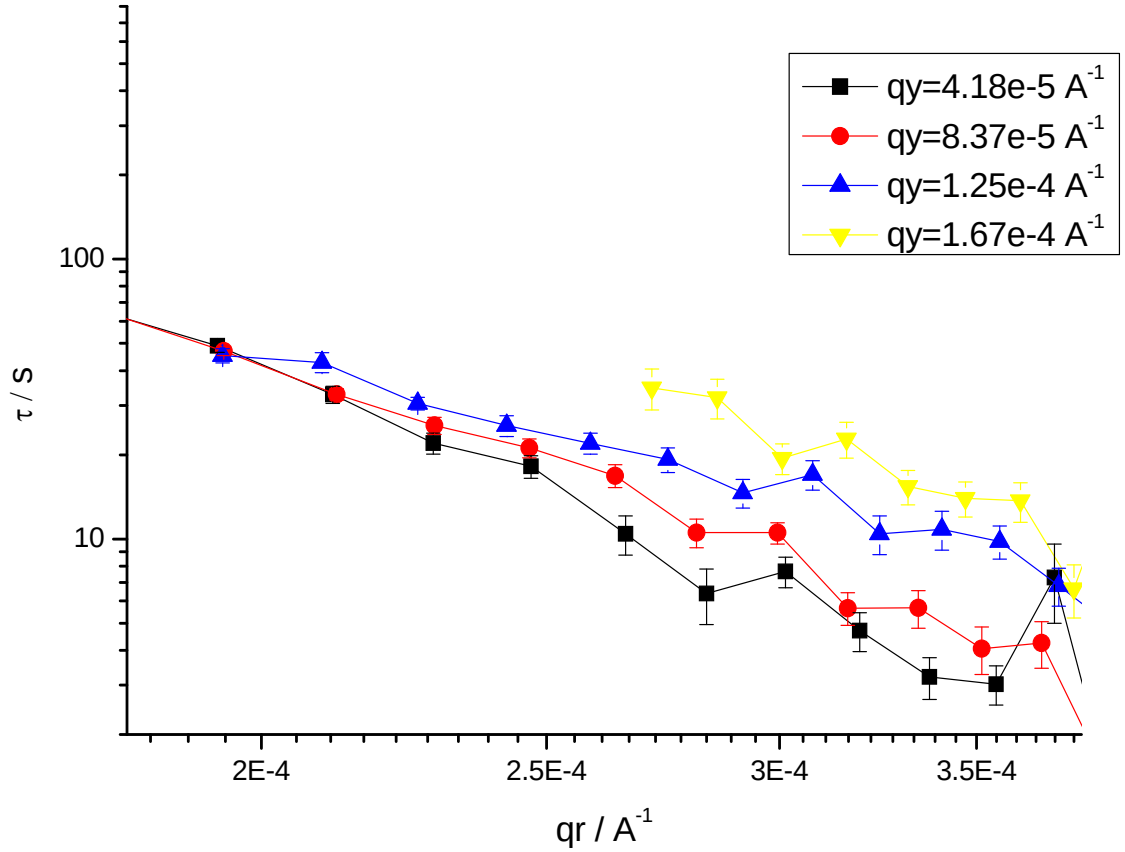


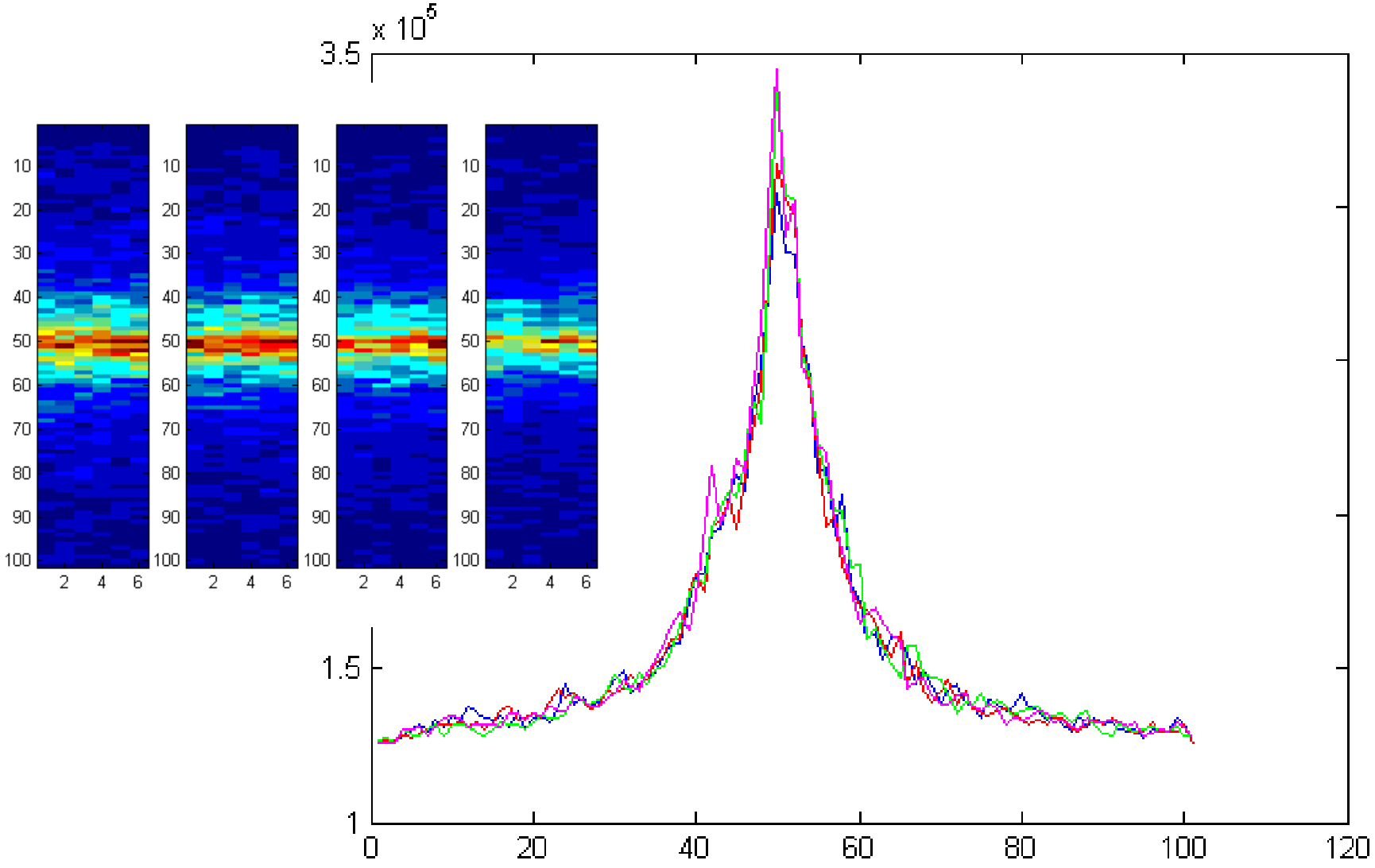
Fig. 1. The experimental setup for XPCS in reflectivity geometry.





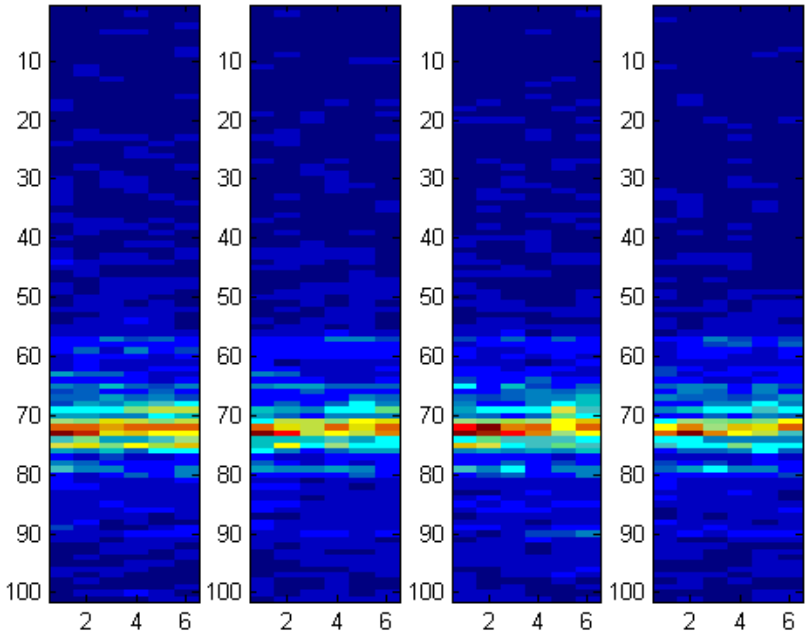
A2: different in two directions

LS4(overfilled, shows dynamics)
strips(y=100,x=6 pixels) taken from original data. frame 11-60 blue, 61-110 red, 111-160 green, 161-210 magenta

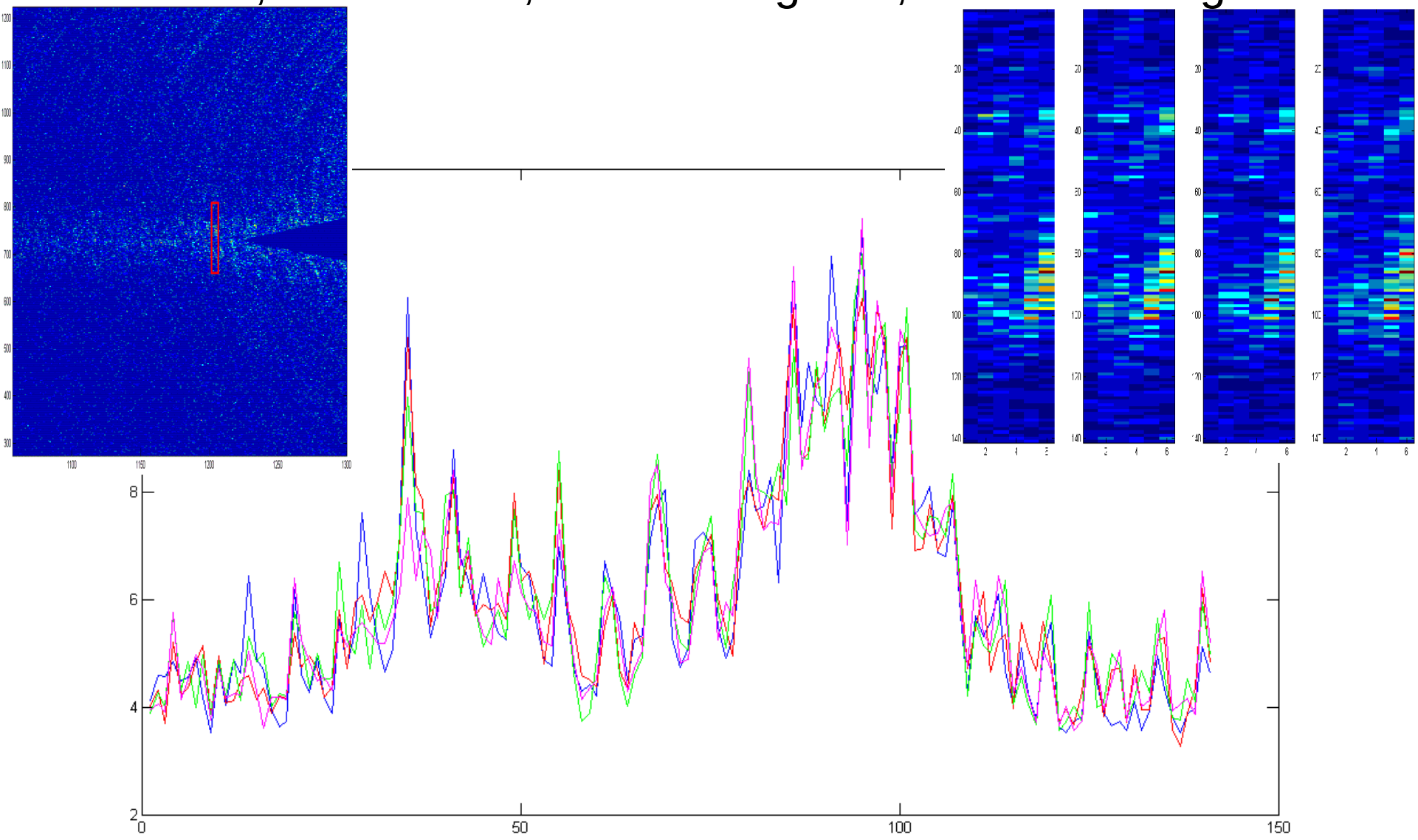


LS1 (underfilled, shows static)

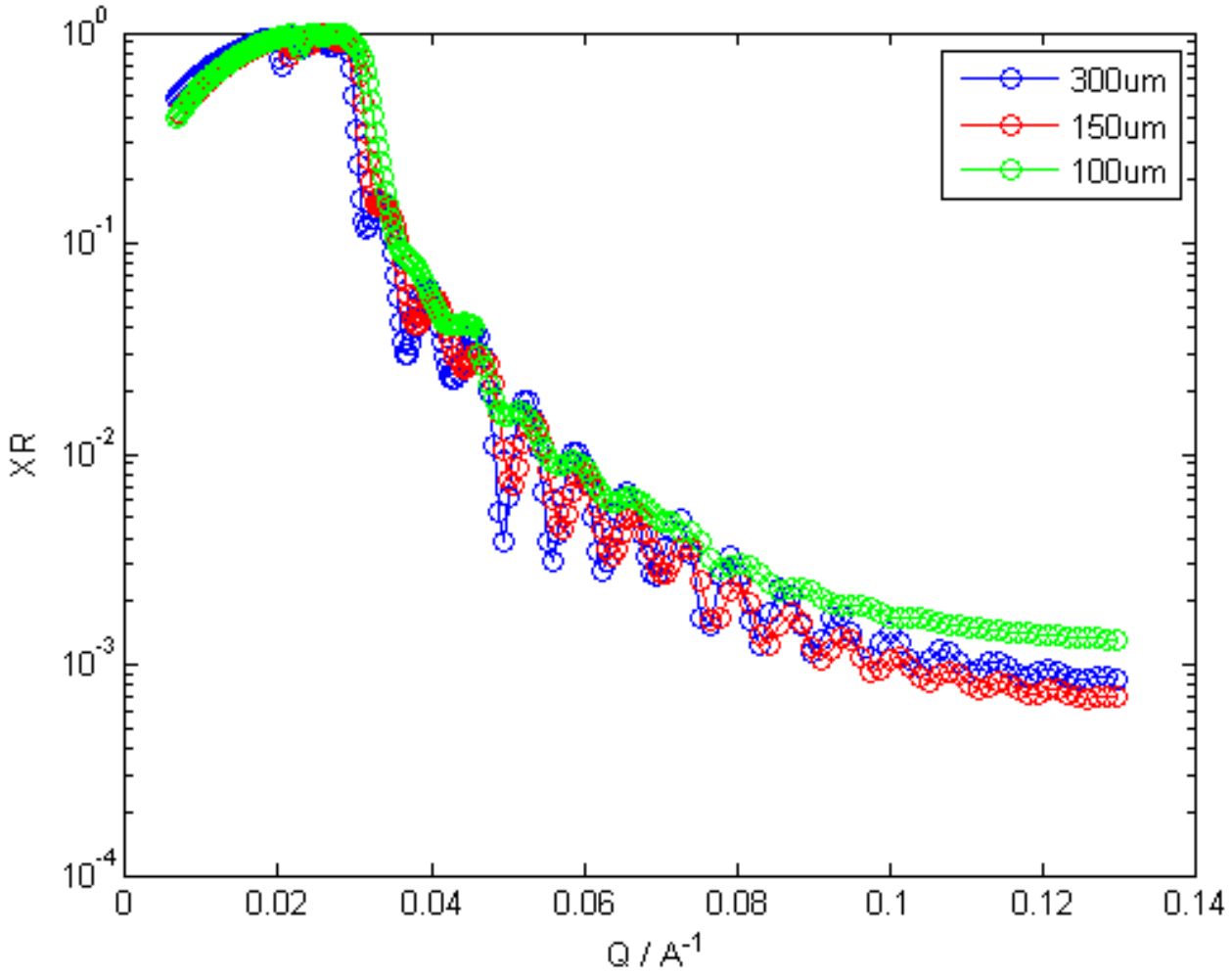
strips(y=100,x=6 pixels) taken from original data. frame 11-60 blue, 61-110 red, 111-160 green, 161-210 magenta



TGZ11(7.5um channels, static or very slow dynamics) strips(y=100,x=6 pixels) taken from original data. frame 11-60 blue, 61-110 red, 111-160 green, 161-210 magenta



XR for different width channels
Thickness ~ 95nm



100um: 98.5~99.5 nm
150um: 94.1~ 97.2nm
300um: 94.1nm